reaction was carried out in aqueous ethanol. Three hundred milligrams of 5(or 4)-(dibutyltriazeno)imidazole-4(or 5)-carboxamide was dissolved in 30 ml. of ethanol at room temperature. The solution was diluted with 60 ml. of water, and a small additional quantity of ethanol was added to redissolve a small amount of the dibutyltriazene precipitated by the addition of the water. The solution was stirred in the presence of light for 2 days, the solvents were removed under reduced pressure, and 122 mg. of crystals (explosive decomposition at 201–204°) were obtained by recrystallizing the residue from 2.5 ml. of water. This material was identical with 2-azahypoxanthine according to paper chromatography.[14] The infrared spectrum was similar to that of 2-azahypoxanthine monohydrate, but C—H absorption bands at 2875, 2930, and 2960 cm.$^{-1}$ indicated that the crystals contained dibutylamine, which was probably present as the dibutylammonium salt of 2-azahypoxanthine. Accordingly, a portion (110 mg.) of the product was dissolved in 2.5 ml. of water and reprecipitated by lowering the pH to 1–2 with hydrochloric acid: weight, 60 mg. (adjusted yield, 38%); explosive decomposition, 204–208°. The infrared spectrum was identical with that of a specimen of 2-azahypoxanthine monohydrate.[3] Paper chromatograms[14] developed in four solvent systems showed only 2-azahypoxanthine.

Ultraviolet spectra were recorded with a Cary Model 14 recording spectrophotometer. Solutions of the 5(or 4)-(disubstituted-triazeno)imidazole-4 (or 5)-carboxamides were protected from light during their preparation, and stock solutions were stored in the dark. During studies on the stability of a triazene derivative, a fresh portion of the stock solution was transferred to the spectrophotometer cell for the tracing of each curve at a given ΔT or ΔT_L. After a triazene had been shown to be stable for 24–48 hr. in the dark, the solution being studied was exposed to indirect sunlight. ΔT_L is the time interval between the initial exposure of a solution to light and the tracing of a given curve, and it includes periods of darkness for studies that extended beyond 8 hr. The wavelength of the radiation catalyzing the dissociation was not determined. Data from the first curves traced during the stability studies (ΔT = 1–7 min.) are included in Table I. Since the stability studies show that the triazenes (except XIII in 0.1 *N* hydrochloric acid) are stable in the dark, ΔT values for the remainder of the determinations summarized in Table I were somewhat greater; but they were usually less than 45 min.

Infrared spectra were determined, using the potassium bromide disc method, with either a Perkin-Elmer Model 21 double-beam spectrophotometer, equipped with a sodium chloride prism, or with a Model 221-G, equipped with a sodium chloride prism and a 240 line-per-mm. grating. Some of the bands, exclusive of aliphatic C—H bands, that appear to be common to most or all of the triazenoimidazoles occur in the following regions (in cm.$^{-1}$): 3390–3350s (sharp), 3305–3260w, 3170–3130m (broad), 2760–2730w (or sh.), 2600w (broad), 1660–1650s (amide I), 1610–1590s, 1555–1545w, 1085–1075ms, 880–850wm, 800–780wm, 700–685wm. Several strong bands appear in the spectra of all of the triazenes in the region 1500–1250 cm.$^{-1}$, especially near 1400 cm.$^{-1}$, but association of these bands with the triazenoimidazolecarboxamide structure is complicated by C—H absorption in the alkyl groups. Bands characteristic of monosubstituted phenyl groups at 770–760 cm.$^{-1}$ and at 690 cm.$^{-1}$ in the spectra of the dibenzyl (X) and the methylphenyl (XIII) triazenes are readily distinguishable from weak or medium bands near these regions in the other triazenes.

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Thiadiazoles. I. Synthesis and Properties of [1,2,5]Thiadiazolo[3,4-*d*]pyrimidines[1]

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[1,2,5]Thiadiazolo[3,4-*d*]pyrimidines have been synthesized from 4,5-diaminopyrimidines and *N*-sulfinylaniline. An intermediate in this reaction has been isolated. Replacement reactions have been observed to occur readily at position 7, and reductive cleavage of the thiadiazole ring has been demonstrated. Similarities in the properties of [1,2,5]thiadiazolo-[3,4-*d*]pyrimidines and pteridines have been noted.

[1,2,5]Thiadiazolo[3,4-*d*]pyrimidines (8-thiapurines) may be considered analogs of two biologically important heterocyclic ring systems: They are formally analogous to the purines[2] by virtue of the 3,4-*d* fusion of the five-membered ring to the pyrimidine ring, and they are iso-π-electronic with the pteridines.[4] Schrage and Hitchings[5] proposed

(1) This investigation was supported by the Cancer Chemotherapy National Service Center, National Cancer Institute, National Institutes of Health, Contract No. SA-43-ph-1740, and by the C. F. Kettering Foundation.

(2) Biological analogy is suggested by the report[3] of antiguanine activity by 8-thiaguanine.

(3) G. M. Timmis, *J. Pharm. Pharmacol.*, **9**, 85 (1957).

(4) The electronic similarity of structures differing only in the substitution of a sulfur atom for an ethylenic grouping is well known: for example, H. C. Longuet-Higgins, *Trans. Faraday Soc.*, **45**, 173 (1949); J. de Heer, *J. Am. Chem. Soc.*, **76**, 4802 (1954); J. Koutecký, *Collection Czech. Chem. Comm.*, **24**, 1608 (1959). *Cf.* O. Hinsburg, *J. prakt. Chem.*, **93**, 302 (1916). This type of substitution has frequently been used in applying the concept of bio-isosterism. Consult, for example, H. L. Friedman, "Influence of Isosteric Replacements upon Biological Activity," First Symposium on Chemical-Biological Correlation, National Research Council-National Academy of Sciences Publication **206**, Washington, D. C., 1951; V. B. Schatz in A. Burger's "Medicinal Chemistry," 2nd ed., Interscience Publishers, Inc., New York, 1960, Chap. 8.

(5) A. Schrage and G. H. Hitchings, *J. Org. Chem.*, **16**, 207 (1951).

[1,2,5]thiadiazolo[3,4-*d*]pyrimidine structures for the product of a reaction of sulfur dichloride and 4,5,6-triaminopyrimidine (I. X = NH_2; Y = H) and for two compounds that were evidently formed by a series of transformations resulting from the action of sulfuryl chloride on 4,5,6-triamino-2-(methylthio)pyrimidine (I. X = NH_2; Y = CH_3S). Blicke and Godt[6] prepared 8-thiatheophylline from thionyl chloride and 4,5-diamino-1,3-dimethyluracil. Timmis[7] synthesized several derivatives, including the analogs of adenine, guanine, xanthine, and theophylline, by employing the reaction of 4,5-diaminopyrimidines with thionyl chloride and by fusing 4-amino-5-nitrosopyrimidines with thiourea.

Since benzothiadiazoles had been prepared[8,9] by the reaction of *o*-phenylenediamines with *N*-sulfinylaniline, as well as with thionyl chloride, it appeared that [1,2,5]thiadiazolo[3,4-*d*]pyrimidines might be prepared under mild conditions by utilizing *N*-sulfinylamines to form the thiadiazole ring. Exploratory studies of the action of *N*-sulfinylaniline (II) on several 4,5-diaminopyrimidines, in different solvent media, resulted in the isolation of 7-amino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (VI) in 94% yield from a reaction of 4,5,6-triaminopyrimidine and II in anhydrous pyridine. This procedure proved to be of general applicability, and a number of derivatives (III–XVII), including the analogs of hypoxanthine and purine-6(1*H*)-thione (6-mercaptopurine), were synthesized.[11] Unlike sulfuryl chloride,[5] *N*-sulfinylaniline converted 4,5,6-triamino-2-(methylthio)pyrimidine to the [1,2,5]thiadiazolo-[3,4-*d*]pyrimidine VIII without complications.

Pyrimidine free bases were used in most of these reactions; but, when 2,5,6-triaminopyrimidin-4-(3*H*)-one proved to be too unstable, the sulfate was used. Other [1,2,5]thiadiazolo[3,4-*d*]pyrimidines bearing oxo or thioxo functions at positions 5 or 7 could also be prepared in good yields from salts of the appropriate 4,5-diaminopyrimidines. When pyrimidine salts were used, the amount of *N*-sulfinylaniline was increased to compensate for decomposition of some of the reagent. Ultraviolet absorption data indicated that 8-thiapurine formation occurred when salts of the more basic pyrimidines 4,5,6-triaminopyrimidine and 2,4,5,6-tetraaminopyrimidine were employed, but 7-amino- (VI) and 5,7-diamino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (IX) were more easily obtained by using the pyrimidine free bases. The 7-amino derivative (VI) was also prepared by using 4-nitro-*N*-sulfinylaniline at room temperature. *N*-Sulfinylanilines having electron-withdrawing substituents should react more readily because of the increase in charge, in the positive direction, on the sulfur atom.[13] Such electronegatively substituted *N* - sulfinylanilines may be useful in forming the 1,2,5-thiadiazole ring from diamines having very sensitive groups.

The formation of benzothiadiazoles from *o*-phenylenediamines has been postulated[9a] to proceed by way of bis(sulfinylamines) such as XVIII. An intermediate in the conversion of 4,5,6-triamino-2-methylpyrimidine (I. X = NH_2; Y = CH_3) to 7-amino-5-methyl[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (VII) was isolated and found to have the composition of either an *N*-(sulfinyl)aminopyrimidine (XIX) or a cyclized isomer (*e.g.*, XX). Kresze and Maschke[13c] have ascribed bands that appear in the spectra of *N*-sulfinylanilines in the region 1137–1178 cm.$^{-1}$ and near 1300 cm.$^{-1}$ to absorption by the NSO group. The presence of bands at 1180, 1300, and 1330 cm.$^{-1}$ in the spectrum of the intermediate, therefore, is consistent with structure XIX. The sulfinylamino group is placed at position 5, rather than position 4, because amine reactions such as acylation occur preferentially at position 5 in 4,5-diaminopyrimidines.[14] Heating the intermediate in pyridine solution under the conditions used in the synthesis of the [1,2,5]thiadiazolo[3,4-*d*]-pyrimidines gave both 7-amino-5-methyl[1,2,5]-thiadiazolo[3,4-*d*]pyrimidine (VII) and 4,5,6-triamino-2-methylpyrimidine. The pyrimidine could have arisen from decomposition of some of the unchanged intermediate during the isolation and characterization. It seems more likely that a disproportionation occurred, part of the intermediate serving as reagent for the conversion of the remainder to VII; for a reaction under identical conditions except for the addition of one equivalent of *N*-sulfinylaniline gave a 96% yield of VII.

During the studies on the synthesis of [1,2,5]-thiadiazolo[3,4-*d*]pyrimidines, replacement reactions at position 7 were observed to occur with considerable facility. The reaction of 4,5-diamino-6-chloropyrimidine (XXI. X = Cl) with *N*-sulfinylaniline—at the usual temperature of 90°—gave 7-anilino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (III), identical with the product prepared from 4,5-diamino-6-anilinopyrimidine. The 7-anilino derivative must have been formed from 7-chloro[1,2,5]-thiadiazolo[3,4-*d*]pyrimidine (XXII) and aniline, the products expected from the reaction of the chloropyrimidine and II. Similarly, the reaction of 5,6-diaminopyrimidine-4(3*H*)-thione (XXI, thiol

(6) F. F. Blicke and H. C. Godt, Jr., *J. Am. Chem. Soc.*, **76**, 2798 (1954).

(7) G. M. Timmis, *J. Chem. Soc.*, 804 (1958).

(8) A. Michaelis, *Ann.*, **274**, 263 (1893).

(9) (a) V. G. Pesin, A. M. Khaletskiĭ, and Chi-Chun Chao, *Zhur. Obshcheĭ Khim.*, **27**, 1570 (Eng. transl.,[10] p. 1643) (1957); (b) A. M. Khaletskiĭ, V. G. Pesin, and Chi-Chun Chao, *Doklady Akad. Nauk SSSR*, **106**, 88 (1956); *Chem. Abstr.*, **50**, 13885c (1956).

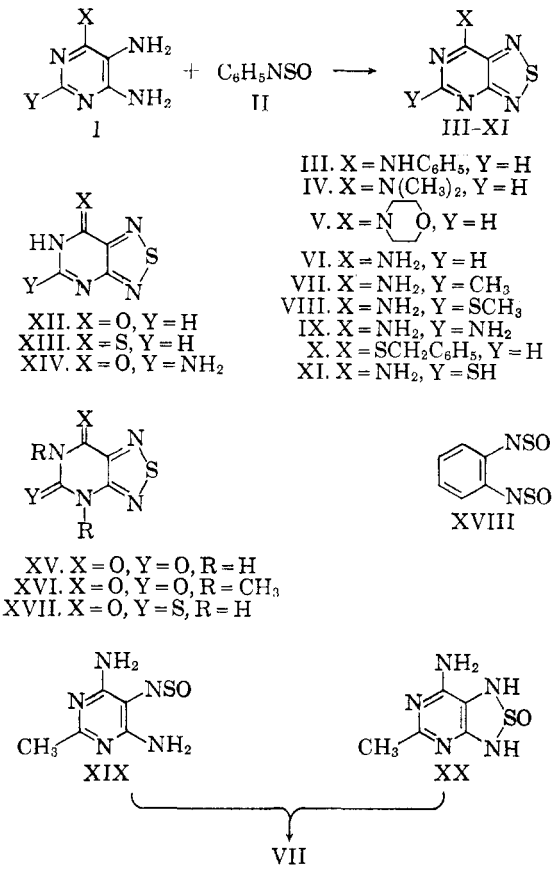
(10) *J. Gen. Chem. USSR* (Eng. Transl.), Consultants Bureau Inc., New York.

(11) After this work had been completed, a publication[12] reporting the use of *N*-sulfinylaniline to prepare XVII and some derivatives described previously[6,7] became available to us.

(12) V. G. Pesin, A. M. Khaletskiĭ, and L. V. Zolotova-Zolotukhina, *Zhur. Obshcheĭ Khim.*, **29**, 3214 (Eng. transl.,[10] p. 3178) (1959); *Chem. Abstr.*, **55**, 560g (1961).

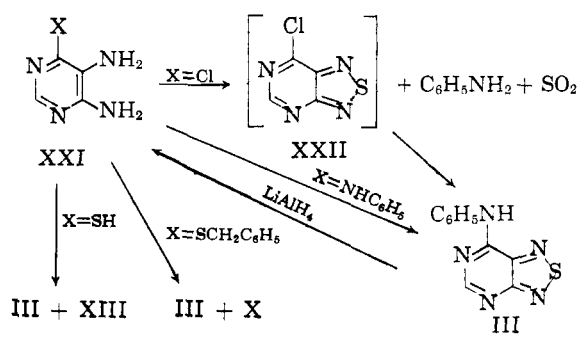
(13) (a) K. A. Jensen and N. H. Bang, *Ann.*, **548**, 95 (1941); (b) G. Leandri and A. Mangini, *Spectrochim. Acta*, **15**, 421 (1959); (c) G. Kresze and A. Maschke, *Chem. Ber.*, **94**, 450 (1961).

(14) G. W. Kenner and A. Todd, "Heterocyclic Compounds," Vol. 6, R. C. Elderfield, ed., J. Wiley and Sons, Inc., New York, 1957, Chap. 7.



form when X = SH) and II produced the 7-anilino derivative, as well as [1,2,5]thiadiazolo[3,4-*d*]pyrimidine-7(6*H*)-thione (XIII). The yield of the 7(6*H*)-thione (XIII) was improved by allowing the reaction to proceed at a lower temperature. 7-Anilino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine was also formed during the reaction of 4,5-diamino-6-(benzylthio)pyrimidine with II.

Cleavage of the thiadiazole ring resulted from reduction of 7-anilino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (III) with lithium aluminum hydride, the product being 4,5-diamino-6-anilinopyrimidine. In addition, the isolation of 5,6-diaminopyrimidine-4(3*H*)-thione from a reaction of 7-amino[1,2,5]-thiadiazolo[3,4-*d*]pyrimidine with hydrogen sulfide in pyridine showed that reductive cleavage of the thiadiazole ring, as well as exchange of the amino group for a thione group, had occurred.



Similarities in the properties of [1,2,5]thiadiazolo-[3,4-*d*]pyrimidines and pteridines support the postulated analogy between the two ring systems. Reductive cleavage of the thiadiazole ring is reminiscent of the preferential reduction of the pyrazine ring of pteridines.[15,16b] Most of the [1,2,5]-thiadiazolo[3,4-*d*]pyrimidines prepared are yellow crystalline solids. Like the pteridines,[16-18] they produce spots on paper chromatograms that are fluorescent—frequently blue or violet—under ultraviolet light.[19] The ultraviolet spectra of [1,2,5]-thiadiazolo[3,4-*d*]pyrimidines show a strong resemblance to published spectra of pteridines.[15,16,20] In aqueous solutions the spectra characteristically exhibit three absorption maxima that usually fall within the regions 220–245 mμ, 260–290 mμ, and 340–380 mμ, the exact wave lengths depending, of course, on the pH and the nature of the substituents. (The middle maximum is usually the least

TABLE I

ULTRAVIOLET ABSORPTION OF [1,2,5]THIADIAZOLO[3,4-*d*]-PYRIMIDINES AND THEIR PTERIDINE ANALOGS

Compound	pH	λ^{a}_{max} (log ε)
XII	1[b]	225(4.1)
		247(3.43)
		310(3.97)
4-Hydroxypteridine[c,d]	5.6	230(3.98)
		265(3.54)
		310(3.82)
VI	7	230(4.13)
		273(3.72)
		280(sh.)
		340(3.91)
4-Aminopteridine[d]	7.3	244(4.20)
		270sh.(3.28)
		335(3.82)
XIII	1	249(4.2)
		386(4.12)
4-Mercaptopteridine[c,d]	4.1	256(4.13)
		390(4.00)
IV	7	234(4.21)
		275(3.66)
		283(sh.)
		368(4.08)
4-Dimethylaminopteridine[d]	7.07	241(4.16)
		255sh.(4.02)
		315sh.(3.36)
		362(3.92)

[a] In mμ. [b] Curve at pH 7 is similar. [c] Ref. 16a. [d] Ref. 21.

(15) A. Albert, *Quart. Revs.*, **6**, 197 (1952).

(16) (a) A. Albert, D. J. Brown, and G. Cheeseman, *J. Chem. Soc.*, 474 (1951); (b) A. Albert, D. J. Brown, and G. Cheeseman, *ibid.*, 1620 (1952).

(17) H. Kwietny and F. Bergmann, *J. Chromatography*, **2**, 162 (1959).

(18) R. Tschesche and F. Korte, *Chem. Ber.*, **84**, 641, 801 (1951).

(19) The following solvent systems were used for paper chromatography: (1) butanol saturated with water, (2) butanol–acetic acid–water (5:2:3 by volume), (3) 2-propanol–water–concd. aqueous ammonia (70:25:5 by volume), and (4) phosphate buffer (pH 7) or acetate buffer (pH 6.1). Chromatograms were examined under two ultraviolet lamps that emit principally at 365 mμ and at 254 mμ.

(20) F. Bergmann and H. Kwietny, *Biochim. Biophys. Acta*, **33**, 29 (1959).

(21) S. F. Mason, "The Chemistry and Biology of Pteridines," A Ciba Foundation Symposium, G. E. W. Wolstenholme and M. P. Cameron, ed., Little, Brown and Co., Boston, 1954, pp. 74–92.

intense and may appear as a plateau or shoulder.) The general similarity of the spectra of [1,2,5]-thiadiazolo[3,4-*d*]pyrimidines and pteridines is illustrated in Table I.

The [1,2,5]thiadiazolo[3,4-*d*]pyrimidines are represented by the *o*-quinoid structure traditionally used for benzothiadiazoles. Strong bands at 1690–1680 cm.$^{-1}$ in the infrared spectra of compounds XII, XIV, and XVII support the amide, rather than the enol, forms; XV and XVI give rise to two strong carbonyl bands at 1690–1670 and at 1720 cm.$^{-1}$. In the region of ring absorption the spectra of compounds IV and V, which do not have tautomeric forms, show strong bands near 1570 and 1520 cm.$^{-1}$ and medium bands near 1500 and 1415 cm.$^{-1}$. The spectra of the remaining [1,2,5]thiadiazolo-[3,4-*d*]pyrimidines include at least two of these bands in addition to bands at higher frequencies due to amino or carbonyl groups.

Experimental[19,22]

4,5-Diaminopyrimidine Free Bases.—Adding an inorganic base to aqueous solutions or suspensions of some of the 4,5-diaminopyrimidine salts either gave low yields of the free bases or precipitated mixtures of the free bases and their salts. When simple precipitation by inorganic base was not satisfactory, the following method was used. An aqueous solution, or suspension, of the pyrimidine sulfate or hydrochloride was made basic with concd. aqueous ammonia, and the resulting mixture was subjected to continuous liquid-liquid extraction with ethyl acetate. The ethyl acetate extract was concentrated, if necessary, and the crystalline free base was separated by filtration. The following pyrimidines were obtained (yields in parentheses) by this method: 4,5,6-triamino- (92%), 4,5,6-triamino-2-methyl- (80%), 4,5,6-triamino-2-(methylthio)- (64%), and 2,4,5,6-tetraaminopyrimidine (58%). When the tetraaminopyrimidine was being extracted, several fresh portions of ethyl acetate were used in order to avoid prolonged heating of the free base.

4,5-Diamino-6-anilinopyrimidine and 4,5-diamino-6-morpholinopyrimidine were prepared by the method of Daly and Christensen[23] except that ethyl acetate was the solvent in the reduction of 4-amino-6-anilino-5-nitropyrimidine. 4,5-Diamino-6-anilinopyrimidine, reported[23] as the sulfate, was obtained in 89% yield as the free base and was recrystallized from benzene; m.p., 171–172° dec.

Anal. Calcd. for $C_{10}H_{11}N_5$: C, 59.66; H, 5.51. Found: C, 59.93; H, 5.48.

4,5-Diamino-6-morpholinopyrimidine, reported[23] as the crude free base, was obtained in 90% yield and recrystallized from ethanol; m.p., 199°.

Anal. Calcd. for $C_8H_{13}N_5O$: C, 49.22; H, 6.71; N, 35.88. Found: C, 49.28; H, 6.70; N, 36.19.

[1,2,5]Thiadiazolo[3,4-*d*]pyrimidines.—Initial studies with *N*-sulfinylaniline[24] (II) in anhydrous mixtures of benzene and ethanol or in anhydrous dioxane[25] gave evidence of 8-thiapurine formation; but, in general, reactions in these solvent media did not give satisfactory results, although the amino derivative (VI) was obtained from an ethanol–benzene reaction mixture. The ultraviolet spectrum of an analytically pure specimen of *N*-sulfinylaniline in absolute ethanol changed rapidly, the change in λ_{max} from 314 mμ to 284 mμ indicating decomposition to aniline. For this reason it appeared that ethanolic solutions would not consistently give good results unless large amounts of II were used.[27]

General Procedure.—*N*-Sulfinylaniline was added to a solution or a suspension of a 4,5-diaminopyrimidine in anhydrous pyridine (dried with calcium hydride). For each millimole of the 4,5-diaminopyrimidine, 3–3.1 mmoles (0.34 ml.) of *N*-sulfinylaniline and 10 ml. of pyridine were used. When a pyrimidine salt was employed, the proportion of *N*-sulfinylaniline was increased to 6 mmoles. The reaction mixture was heated at 90–95°, unless otherwise stated, and throughout the course of the reaction the mixture was kept under a nitrogen atmosphere and was protected from atmospheric moisture with a tube of calcium sulfate or calcium chloride. The time required for completion of the reaction was estimated from ultraviolet spectra given by reaction aliquots.

The typical isolation procedure consisted of the following steps. The reaction mixture was evaporated to dryness under reduced pressure. Several portions of ethanol–water mixtures were added to the residue and evaporated under reduced pressure to aid in the removal of traces of pyridine and aniline. The residue was triturated with aqueous ethanol, and the product was removed by filtration and dried *in vacuo* over phosphorus pentoxide. A small second crop of product was frequently isolated from the filtrate. Exceptions to the general procedure are outlined below.

7-Anilino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (III) was obtained in 92% yield (m.p. 180°) from 4,5-diamino-6-anilinopyrimidine after a reaction time of 4 hr. The infrared and ultraviolet spectra were identical with those of the analytical sample obtained from 4,5-diamino-6-chloropyrimidine (below).

7-Dimethylamino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (IV) was obtained in 82% yield from 4,5-diamino-6-dimethylaminopyrimidine[28] after a reaction time of 4.5 hr. at 106–110°. Sublimation under reduced pressure and recrystallization of the sublimate from water gave the analytical sample as yellow crystals; m.p., 175°. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 227 (13.7), 266 (5.0), 275 (sh.), 348 (17.0) at pH 1; 234 (16.3), 275 (4.6), 283 (sh.), 368 (12.0) at pH 7; 234 (16.1), 275 (4.6), 283 (sh.), 368 (11.8) at pH 13.

Anal. Calcd. for $C_6H_7N_5S$: C, 39.76; H, 3.89; N, 38.65; S, 17.69. Found: C, 39.93; H, 3.84; N, 38.48; S, 17.35.

7-Morpholino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (V) was prepared from 4,5-diamino-6-morpholinopyrimidine in 86% yield (m.p. 156–157°) using a reaction time of 3 hr. The yellow crystals obtained by recrystallizing the product from water melted at 157°. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 229 (13.0), 268 (5.2), 355 (17.7) at pH 1; 235 (17.1), 277 (4.5), 285 (sh.),

(22) Spectra were recorded with the following spectrophotometers: ultraviolet spectra with a Cary Model 14 or a Beckman Model DK-2 (with optical densities at the maxima measured with a Beckman Model DU); infrared spectra with a Perkin-Elmer Model 21 or a Perkin-Elmer Model 221. Ultraviolet and infrared spectra for all compounds, known or unknown, were determined on samples that gave satisfactory elemental analyses. The potassium bromide disc method was used in recording infrared spectra. Ultraviolet spectra were determined in 0.1 *N* hydrochloric acid (pH 1), phosphate buffer (pH 7), and 0.1 *N* sodium hydroxide (pH 13); "sh." designates the estimated wave length of a shoulder or inflection. Unless noted otherwise, melting points were determined on a Kofler Heizbank melting point apparatus and are corrected. Other melting points were determined in capillary tubes heated either in an oil bath or in an aluminum block.

(23) J. W. Daly and B. E. Christensen, *J. Org. Chem.*, **21**, 177 (1956).

(24) A. Michaelis, *Ber.*, **24**, 745 (1891).

(25) The ultraviolet spectrum (λ_{max} 314 and 232 mμ) of *N*-sulfinylaniline in anhydrous dioxane was essentially unchanged after 24 hr. at room temperature. This evidence of stability in dioxane is in accord with the stability of *N*-sulfinylaniline in ether.[26a]

(26) (a) W. T. Smith, Jr., D. Trimnell, and L. D. Grinninger, *J. Org. Chem.*, **24**, 664 (1959); (b) W. T. Smith, Jr., and L. D. Grinninger, *ibid.*, **26**, 2133 (1961); (c) P. Carré and D. Libermann, *Compt. rend.*, **194**, 2218 (1932).

(27) See, however, footnotes 24 and 26 for reports that *N*-sulfinylaniline is stable in ethanol but not in methanol.

(28) C. L. Leese and G. M. Timmis, *J. Chem. Soc.*, **1958**, 4104.

371 (12.0) at pH 7; 236 (17.0), 278 (4.9), 288 (3.8), 377 (11.6) in ethanol.

Anal. Calcd. for $C_8H_9N_5OS$: C, 43.05; H, 4.06; N, 31.38; S, 14.36. Found: C, 43.18; H, 4.36; N, 31.23; S, 14.34.

7-Amino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (VI). —a. The general procedure, with a reaction time of 4.75 hr. at 110°, afforded VI as yellow crystals (m.p. 250°) in 94% yield from 4,5,6 triaminopyrimidine free base.

b. A mixture of 180 mg. of 4,5,6-triaminopyrimidine, 865 mg. of 4-nitro-*N*-sulfinylaniline,[13a,24] and 15 ml. of anhydrous pyridine was stirred at room temperature. The reaction mixture did not become homogeneous, and the solid phase (100 mg., m.p. 250°) was separated by filtration after 92 hr. and identified as VI. Additional crude VI (94 mg.) was isolated from the filtrate and recrystallized from water. The recrystallized material (33 mg., m.p. 248–250°) raised the yield to 61%.

c. A mixture of 500 mg. of 4,5,6-triaminopyrimidine, 1.35 ml. of II, 50 ml. of ethanol, and 10 ml. of benzene was heated at the reflux temperature for 6 hr., cooled, and filtered to remove the crude yellow product [450 mg., m.p. 243–248° (oil bath)]. Two recrystallizations from water afforded a specimen that gave satisfactory elemental analyses and melted at 253° (lit.,[7] 248°). λ_{max}[29] in mμ ($\epsilon \times 10^{-3}$): 217 (11.4), 267 (3.9), 327 (12.1) at pH 1; 223 (sh.), 230 (13.4), 273 (5.3), 280 (sh.), 340 (8.1) at pH 7.

7-Amino-5-methyl[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (VII).—A mixture of 517 mg. (3.7 mmoles) of the pyrimidine free base, 22 ml. of dry pyridine, and 1.27 g. (1.03 ml., 9.2 mmoles) of *N*-sulfinylaniline was heated at 90° for 3.5 hr. The formation and dissolution of a heavy yellow precipitate was observed (*cf.* below). A crop of yellow crystals [413 mg., m.p. 225–226° (oil bath)] was obtained by allowing the reaction solution to remain at room temperature overnight; a second crop (114 mg.) raised the yield of crude product to 84%. The analytical sample, m.p. 225–226° (oil bath), was prepared by recrystallizing the first crop from water. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 218 (13.0), 268 (5.8), 327 (12.7) at pH 1; 231 (15.3), 277 (5.9), 342 (8.0) at pH 7; 230 (14.1), 274 (4.8), 253 (sh.), 345 (6.3), 380 (sh.) at pH 13.

Anal. Calcd. for $C_5H_5N_5S$: C, 35.91; H, 3.01; N, 41.89; S, 19.18. Found: C, 36.16; H, 3.10; N, 41.91; S, 19.09

7-Amino-5-(methylthio)[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (VIII).—A reaction mixture, prepared in the usual manner, was heated for 6 hr., allowed to stand at room temperature overnight, and heated again for 5 hr. Recrystallization of the crude product (83% yield, m.p. 204–206°) from ethanol or from water gave yellow crystals; m.p., 207–209°. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 225 (12.0), 314 (12.4), 339 (15.2) at pH 1; 241 (19.7), 253 (sh.), 311 (8.1), 354 (9.8) at pH 7; 240 (17.9), 255 (sh.), 309 (7.6), 359 (8.3) at pH 13.

Anal. Calcd. for $C_5H_5N_5S_2$: C, 30.14; H, 2.53; N, 35.15; S, 32.18. Found: C, 30.15; H, 2.89; N, 34.73; S, 32.40.

5,7-Diamino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (IX) was isolated in 89% yield by filtering the red solid from a reaction mixture that had been heated at the reflux temperature for 30 hr. A solid phase was present throughout the course of the reaction. A specimen of orange needles obtained by recrystallizing the crude product from water gave satisfactory analyses for all elements; m.p., 350–361° dec. (Al block; lit.,[7] 355°). λ_{max} in mμ ($\epsilon \times 10^{-3}$): 295 (sh.), 323 (12.8) at pH 1; 286 (4.8), 359 (7.9) at pH 7; 287 (4.6), 360 (7.8) at pH 13.

7-Amino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine-5(4*H*)-thione (XI) was prepared from 4,5,6-triaminopyrimidine-2(1*H*)-thione sulfate and isolated by filtering the orange product from a reaction mixture that had been heated for 5.5 hr. The analytical sample, prepared by twice precipitating the crude product from basic solutions with acetic acid, was an olive-green solid that did not melt below 320° (oil bath). Its infrared and ultraviolet spectra were identical with those of the original orange product. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 237 (8.3), 277 (21.6), 365 (10.3) at pH 1; 260 (12.0), 317 (9.2), 370 (12.1) at pH 7; 252 (17.6), 272 (11.8), 319 (6.2), 387 (8.9) at pH 13.

Anal. Calcd. for $C_4H_3N_5S_2$: C, 25.94; H, 1.63; N, 37.81; S, 34.62. Found: C, 26.09; H, 1.95; N, 37.69; S, 34.56.

[1,2,5]Thiadiazolo-[3,4-*d*]pyrimidin-7(6*H*)-one (XII).—A reaction of 5,6-diaminopyrimidin-4(3*H*)-one free base and *N*-sulfinylaniline was allowed to proceed in the usual manner for 6 hr. The crude product [92%, m.p. 216–219° (oil bath)] was isolated by adding benzene to the concentrated reaction mixture. White crystals were obtained by recrystallizing the crude yellow precipitate from pyridine–benzene; m.p., 234° dec. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 225 (12.5), 247 (2.7), 310 (9.4) at pH 1; 225 (12.5), 247 (sh.), 311 (8.7) at pH 7; 228 (13.3), 270 (4.7), 337 (7.4) at pH 13.

Anal. Calcd. for $C_4H_2N_4OS$: C, 31.16; H, 1.31; N, 36.35; S, 20.80. Found: C, 31.35; H, 1.75; N, 36.21; S, 20.69.

The pyrimidine sulfate also gave XII (57%, m.p. 230° dec.) after 4.5 hr. at the reflux temperature. Recrystallization of the product from water gave pure material (42% yield, m.p. 234°).

5-Amino[1,2,5]thiadiazolo[3,4-*d*]pyrimidin-7(6*H*)-one[30] (XIV) was prepared from 2,5,6-triaminopyrimidin-4(3*H*)-one sulfate and was isolated, in yields of 80–92%, by filtering the reaction mixture. No further purification of the product was required; m.p., 360–362° dec. (Al block). The melting point reported[7] for the hydrochloride hemihydrate is 380° dec. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 217 (19.4), 310 (9.9), 345 (sh.) at pH 1; 228 (22.3), 255 (sh.), 285 (sh.), 342 (7.2) at pH 7; 228 (17.8), 282 (4.3), 351 (8.0) at pH 13.

Anal. Calcd. for $C_4H_3N_5OS$: C, 28.40; H, 1.79; N, 41.40; S, 18.95. Found: C, 28.56; H, 1.93; N, 41.45; S, 18.89.

[1,2,5]Thiadiazolo[3,4-*d*]pyrimidine-5,7(4*H*,6*H*)-dione[7] (XV).—4,5-Diaminouracil hydrochloride was allowed to react at the reflux temperature for 3 hr., the reaction mixture was concentrated, and the oily residue was triturated with ethanol. Crude XV [m.p. 292–294° dec. (oil bath)] was thereby obtained in 71% yield and was purified by recrystallization from water; m.p., 294–295° dec. (oil bath). λ_{max} in mμ ($\epsilon \times 10^{-3}$): 240 (sh.), 314 (10.5) at pH 1.

4,5-Diaminouracil free base was allowed to react at the reflux temperature for 5.5 hr., and a small quantity of the starting material was removed by filtration. Application of the general isolation procedure to the filtrate gave a 74% yield of crude XV [m.p. 292–294° dec. (oil bath)]. Yellow crystals with a melting point of 294° dec. (oil bath) were obtained by recrystallizing the crude product twice from 0.1 *N* hydrochloric acid, once from water, and once from ethanol.

4,6-Dimethyl[1,2,5]thiadiazolo[3,4-*d*]pyrimidine-5,7(4*H*,6*H*)-dione (XVI), having the same melting point and ultraviolet extinction coefficients as analytically pure material, was isolated in 90% yield after a reaction time of 2 hr. Yellow needles that crystallized from water melted at 154–155° (sealed cap.; lit.,[6,7] 149–151°, 154°) and gave satisfactory analyses for all elements. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 218 (15.6), 255 (3.4), 319 (9.6) at pH 1; 218 (15.5), 255 (3.4), 319 (9.6) at pH 7; 217 (14.5), 255 (3.3), 319 (9.4) in ethanol.

[1,2,5]Thiadiazolo[3,4-*d*]pyrimidin-7(6*H*)-one-5(4*H*)-thione (XVII).—The pyrimidine free base afforded yields of 80–82% of XVII after a reaction time of 2.5 hr. The product was isolated by diluting the reaction mixture (7.5 ml. of pyridine/mmole of pyrimidine) with ethanol or ethanol–water. The yield from the pyrimidine sulfate after 2 hr. at

(29) The maxima and minima at pH 1 reported by Schrage and Hitchings[6] for the product of sulfur dichloride and 4,5,6-triaminopyrimidine are in agreement with those given by our specimens of VI; their reported long wave length maximum at pH 11 is 332 mμ.

(30) Although the use of *N*-sulfinylaniline to prepare compounds XIV–XVII has been reported,[11,12] differences of as much as 3–4% between some of the elemental analyses and the calculated composition suggest that the procedures used may not have given pure products.

100° was 84%. Recrystallization of XVII from water gave yellow crystals; m.p., 290–291° dec. (Al block). λ_{max} in mμ ($\epsilon \times 10^{-3}$): 227 (6.0), 271 (21.4), 343 (13.8) at pH 1; 244 (13.0), 278 (19.2), 364 (8.9) at pH 7.

Anal. Calcd. for $C_4H_2N_4OS_2$: C, 25.80; H, 1.08; N, 30.09; S, 34.44. Found: C, 25.67; H, 1.35; N, 30.13; S, 34.31.

Reaction of 4,5-Diamino-6-chloropyrimidine with *N*-Sulfinylaniline.—The general procedure was employed for the reaction of 4,5-diamino-6-chloropyrimidine and II, during 4 hr., and for the isolation of the product. Recrystallization of the crude product from benzene or from benzene–petroleum ether (b.p. 30–60°) gave yellow needles that proved to be 7-anilino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (III): yield, 55%; m.p., 180°. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 237 (11.5), 263 (sh.), 368 (13.0) at pH 1; 242 (16.3), 276 (5.8), 373 (12.4) at pH 7; 252 (15.9), 402 (12.2) at pH 13.

Anal. Calcd. for $C_{10}H_7N_5S$: C, 52.40; H, 3.08; N, 30.55 S, 13.99. Found: C, 52.20; H, 3.03; N, 30.76; S, 13.87.

Reaction of 5,6-Diaminopyrimidine-4(3*H*)-thione and *N*-Sulfinylaniline.—Paper chromatograms of the total product from a reaction of XXI (X = SH) and II showed 3 strongly fluorescing spots under ultraviolet light: a bright yellow spot consisting of 7-anilino[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (III), a dark gray-black spot that was later shown to be [1,2,5]thiadiazolo[3,4-*d*]pyrimidine-7(6*H*)-thione (XIII), and a bright blue spot. In order to isolate these products 2.84 g. of the pyrimidine was treated with *N*-sulfinylaniline by the general procedure for 6 hr., and the reaction mixture was kept at 5° overnight. Concentration of the red reaction solution yielded an orange solid (896 mg.) that was shown by paper chromatography to be mostly the 7(6*H*)-thione (XIII) contaminated with small amounts of the other two products. Dilution of the filtrate with water and further concentration gave a second orange fraction (2.17 g., m.p. 172–174°). Paper chromatography showed that this fraction was principally the 7-anilino derivative (III), but the black and blue spots were also present. A third, yellow fraction (1.58 g., m.p. 170–172°), obtained by diluting the filtrate from fraction 2 with ethanol and concentrating, consisted of the 7-anilino derivative and the blue fluorescent product. **[1,2,5]Thiadiazolo[3,4-*d*]pyrimidine-7(6*H*)-thione** (XIII) was isolated as orange crystals, m.p. 289–290° dec. (oil bath), by reprecipitating fraction 1 from 3 *N* aqueous ammonia with acetic acid, recrystallizing the precipitate twice from aqueous dimethylformamide, and drying the crystals at 110° for 3 hr. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 249 (15.8), 386 (13.2) at pH 1; 252 (15.0), 288 (4.2), 297 (sh.), 395 (10.3) at pH 7.

Anal. Calcd. for $C_4H_2N_4S_2 \cdot {}^1/_2H_2O$: C, 26.80; H, 1.69; N, 31.44; S, 35.98. Found: C, 27.06; H, 1.47; N, 31.43; S, 35.77.

Fractions 2 and 3 were combined and leached with hot benzene. The benzene extracts yielded 1.48 g. of yellow crystals, m.p. 178–180°, that were shown by paper chromatography and by comparing infrared spectra to be 7-anilino-[1,2,5]thiadiazolo[3,4-*d*]pyrimidine. The blue fluorescent component was not isolated in pure form, but warming the benzene-insoluble material (from fractions 2 and 3) with 3 *N* aqueous ammonia left a small insoluble fraction that, according to paper chromatography, consisted chiefly of the blue fluorescent material.

[1,2,5]Thiadiazolo[3,4-*d*]pyrimidine-7(6*H*)-thione was obtained in 55% yield after XXI (X = SH) and II had reacted at 37° for 17 hr., other conditions being the same as usual. The anhydrous product was isolated by concentrating the reaction mixture, diluting it with 85% ethanol, and leaching the resulting precipitate twice with boiling ethanol. Ultraviolet spectra and paper chromatography showed this material to be identical with the hemihydrate described above.

Reaction of 4,5-Diamino-6-benzylthiopyrimidine with *N*-Sulfinylaniline.—A solution of 465 mg. of 4,5-diamino-6-benzylthiopyrimidine, 835 mg. of *N*-sulfinylaniline, and 25 ml. of anhydrous pyridine was maintained at 50–55° for 7.5 hr. and then evaporated to dryness under reduced pressure at temperatures below 50°. Several portions of water and ethanol were added and re-evaporated. Yellow needles of **7-(benzylthio)[1,2,5]thiadiazolo[3,4-*d*]pyrimidine (X),** obtained by recrystallizing the yellow crystalline residue from ethanol, weighed 222 mg. (44%) and melted at 101°. The melting point was unchanged after a second recrystallization. λ_{max} in mμ ($\epsilon \times 10^{-3}$): 226 (sh.), 290 (7.2), 292 (sh.), 363 (8.4) at pH 1; 232 (11.5), 288 (8.1), 292 (sh.), 362 (11.4) at pH 7; 216 (19.8), 309 (6.5), 335 (sh.) at pH 13.

Anal. Calcd. for $C_{11}H_8N_4S_2$: C, 50.75; H, 3.10; N, 21.52; S, 24.64. Found: C, 51.10; H, 3.41; N, 21.29; S, 24.95.

A second fraction obtained from the ethanol filtrates was shown by paper chromatography and by ultraviolet absorption data to be a mixture of the 7-benzylthio derivative and the 7-anilino derivative. In subsequent reactions on a larger scale the benzylthio derivative was exposed to aniline in the reaction mixture for longer periods during the concentration of the reaction mixture, and the 7-anilino derivative was the principal product. A larger-scale reaction allowed to proceed for 18 hr. under the conditions described above gave an 84% yield of the 7-anilino derivative (III).

Reductive Cleavage. a. Lithium Aluminum Hydride.—A solution of 688 mg. of 7-anilino[1,2,5]thiadiazolo[3,4-*d*]-pyrimidine in 20 ml. of anhydrous tetrahydrofuran was added dropwise during 15 min. to a mixture of 1 g. of lithium aluminum hydride and 200 ml. of anhydrous ether. The reaction mixture was stirred at room temperature for 45 min., water was introduced dropwise, and the resulting mixture was acidified with sulfuric acid. The ether layer was dried with sodium sulfate and freed of the solvent. An ethanol solution of the residue was filtered, and the ethanol was removed *in vacuo*. The dark crystalline residue, which amounted to 420 mg. (70%), was shown to be 4,5-diamino-6-anilinopyrimidine by comparing its infrared and ultraviolet spectra and its paper chromatograms with those of a specimen prepared by reducing 4-amino-6-anilino-5-nitropyrimidine.

b. Hydrogen Sulfide in Pyridine.—A reaction mixture prepared by passing hydrogen sulfide into anhydrous pyridine and then adding 460 mg. of 7-amino[1,2,5]thiadiazolo-[3,4-*d*]pyrimidine was heated in a bomb at 100° for 21 hr. The solvent was evaporated under reduced pressure. The residual solid was dried *in vacuo* at 100° for 3 hr. and was shown by paper chromatography to be identical with 5,6-diaminopyrimidine-4(3*H*)-thione. A sublimate, presumably sulfur, that formed during the drying process melted at 121°. Slurrying the product with water and redrying gave 449 mg. of material, m.p. 255–260° dec. (oil bath), which may have contained some elemental sulfur. The crude product was recrystallized once, with a low recovery, from 2-ethoxyethanol, and twice from water. The purified product, m.p. 266–267° (oil bath), was shown by a carbon-hydrogen analysis, mixture melting point determination, and ultraviolet spectra to be 5,6-diaminopyrimidine-4(3*H*)-thione (XXI. X = SH).

Intermediate in the Formation of 7-Amino-5-methyl[1,2,5]-thiadiazolo[3,4-*d*]pyrimidine. a. Isolation.—To a suspension of 2.07 g. (12 mmoles) of 4,5,6-triamino-2-methylpyrimidine in 85 ml. of dry pyridine at room temperature was added 4.12 ml. (36.6 mmoles) of *N*-sulfinylaniline. A yellow solid began to form before the starting material had completely dissolved. (On a smaller scale, the reaction mixture sometimes became homogeneous before the yellow solid appeared.) The mixture was stirred under anhydrous conditions for 0.5 hr. and filtered. The yellow solid was successively washed with 10 ml. of dry pyridine and with 10 ml. of dry benzene, stirred in 50 ml. of dry pyridine for 15 min. in order to dissolve any starting material, washed with 10 ml. of pyridine and with two 10-ml. portions of benzene, and dried *in vacuo* at room temperature: yield, 1.95 g. (70%); m.p., 180–181° dec. A second portion, obtained by chilling the filtrate, had the same melting point and infrared spec-

trum, and raised the yield to 77%. Although this material gave satisfactory carbon, hydrogen, and nitrogen analyses without further purification, a specimen was recrystallized from absolute ethanol without altering its melting point or infrared spectrum.

Anal. Calcd. for $C_6H_7N_5SO$: C, 32.42; H, 3.81; N, 37.81; S, 17.31. Found: C, 32.56; H, 3.74; N, 37.65; S, 17.37.

Addition of water to an ethanol solution caused the disappearance of the yellow color. A freshly prepared absolute ethanol solution produced absorption maxima at 253 mμ and 408 mμ and an inflection near 350 mμ.

b. Conversion to VII.—The general procedure for the preparation and isolation of [1,2,5]thiadiazolo[3,4-*d*]pyrimidines was used in treating 185 mg. (1 mmole as XIX) of the intermediate with 139 mg. (1 mmole) of *N*-sulfinylaniline in 20 ml. of dry pyridine for 3.5 hr. 7-Amino-5-methyl[1,2,5]-thiadiazolo-[3,4-*d*]pyrimidine (VII) was isolated (96% yield based on XIX) and recrystallized from water. The purified product (80% recovery) was identical by melting point (225°), paper chromatography, and ultraviolet absorption with VII.

An experiment performed in the same way except for the omission of *N*-sulfinylaniline yielded the following fractions: (1) 10 mg. of 4,5,6-triamino-2-methylpyrimidine, identified by paper chromatography; (2) 80 mg. of a mixture, according to paper chromatography and infrared spectra, of 4,5,6-triamino-2-methylpyrimidine and VII; (3) 44 mg. of VII, identified by paper chromatography.

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Base-Catalyzed Ring Opening of *N*-Substituted 5-Isoxazolones[1]

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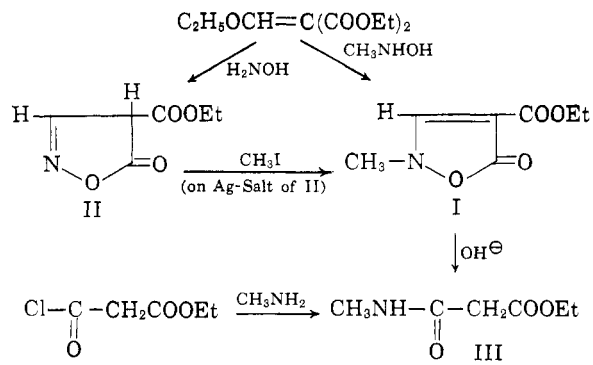
A facile ring opening of *N*-substituted 5-isoxazolones having no substituent in the 3-position is described. Reaction of 2-methyl-4-carbethoxy-5-isoxazolone (I) with dilute alkali or sodium carbonate affords the novel compound, carbethoxymethylacetamide (III). The reaction mechanism sequence probably involves abstraction of a proton from the 3-position as evidenced by the failure of 2,3-dimethyl-4-carbethoxy-5-isoxazolone (IV), also a new compound, to undergo similar ring opening in base. In the reaction of I with aqueous sodium cyanide, cyanide ions compete effectively with hydroxide ions in attack of the activated double bond, yielding ethyl 2-cyano-2-methylaminoacrylate (VI) as the major reaction product, together with some III. The reaction product of I and aqueous sodium azide, ethyl 2-azido-2-methyliminopropionate (VIII), cyclizes under the reaction conditions to ethyl 1-methyl-5-tetrazolylacetate (VII).

In 1897 Claisen[2] obtained 2-methyl-4-carbethoxy-5-isoxazolone (I) on methylation of the silver salt of 4-carbethoxy-5-isoxazolone (II) with methyl iodide. On heating of I with strong alkali, methylamine was formed, thus proving that indeed *N*-methylation had occurred. The author reported that I could be recovered from dilute alkali unchanged.

We have synthesized I from methylhydroxylamine and diethyl ethoxymethylenemalonate and, contrary to the above observations, we found that I undergoes a remarkably facile ring opening in dilute base. When I was added to 5% sodium hydroxide or aqueous sodium carbonate, an immediate exothermic reaction occurred and carbethoxymethylacetamide (III) was isolated and identified by comparison with an authentic sample.

Interestingly, the ring opening of I to III occurred on mild heating even in a weakly basic medium such as sodium acetate solution.

The formation of III may be explained as occurring *via* base attack on the double bond at the



3- position forming the carbanion Ia. Ia could be in equilibrium with its conjugate acid Ib as well as with the less likely carbanion Ic. This carbanion can undergo electron shifts leading to ring opening and decarboxylation yielding the final product. When the base is hydroxide ion, the species IIIa tautomerizes to the amide III.

There are alternate possible mechanisms such as ring opening *via* carbanion Ia with formation of a ketene intermediate or direct abstraction of the proton in I with formation of a keteneimine inter-

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(2) L. Claisen, *Ber.*, **30**, 1480 (1897).